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**Maritimes Region** | **Région des Maritimes**

# Development of Reference Points for Inshore Lobster in the Maritimes Region (LFAs 27-38)

# Élaboration de points de référence pour le homard côtier de la région des Maritimes (zones de pêche du homard 27 à 38)

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## ABSTRACT

Progress in the development of Reference Points (RPs) for lobster in the Maritimes Region is described. The rationale for using empirical (or "trend-based") RPs for lobsters, and for using landings as a proxy for biomass in the near to medium term, is given. In addition, the role of secondary indicators in applying the RPs and in the application of Harvest Control Rules is discussed. Landings are the only biomass proxy that has a significant time series (at least 20 years). Although there are clearly uncertainties in using landings as a proxy for biomass, two lines of evidence indicate that increased landings since the 1980s are primarily the result of increased lobster abundance: 1) the correlation between landings and trap catch rate; and 2) the correlation between landings and lobster catch in fishery independent surveys that record lobsters.

The median of the lobster landings from 1985-2009 is used as a $B_{MSY}$ proxy. For the upper stock reference (USR) and limit reference point (LRP), the values of 80% and 40% are proposed, as is suggested in the Department of Fisheries and Oceans' guidance document on application of the Precautionary Approach. These values are set out for each LFA. Where there were observations of lower landings from 1985-2009 from which the fishery recovered, the lowest point of a 3-year running average was used as the LRP.

Given the uncertainties and caveats associated with the use of landings as a biomass proxy, the proposed RPs should be used only with additional reference to secondary indicators. In addition, steps should be taken to incorporate some fishery independent indicator of abundance. For some Lobster Fishing Areas (LFAs), fishery independent surveys could be in the form of available surveys directed at other species that also record lobsters. Alternatively, periodic directed lobster surveys could be established to monitor the response to conservation measures.

Where time series are available (LFAs 27-33), there has been no upward trend in exploitation for the last 11-12 years. Lobster abundance has continued to increase during the last 11 years in most areas. Under current conditions, lobster stocks appear to have been resilient to the levels of exploitation measured in the last decade or more.

## RÉSUMÉ

On décrit dans le présent document les points de référence pour le homard de la région des Maritimes. La raison pour laquelle on utilise des points référence empiriques (ou « fondés sur des tendances ») pour le homard ainsi que les débarquements comme valeur approximative pour la biomasse à court et à moyen terme est présentée. De plus, il est question du rôle des indicateurs secondaires dans l'application des points de référence et des règles de contrôle des prises. Les débarquements sont la seule valeur approximative de la biomasse ayant une série chronologique importante (au moins 20 ans). Cependant, malgré le fait qu'il existe des incertitudes quant à l'utilisation des débarquements comme valeur approximative de la biomasse, il y a deux preuves indiquant que l'augmentation des débarquements depuis les années 1980 résulte principalement de la plus grande abondance de homard : 1) la corrélation entre les débarquements et le taux de prise par casier et 2) la corrélation entre les débarquements et les prises de homard déterminée à l'aide de relevés indépendants sur la pêche au cours desquels le nombre de homards a été enregistré.

La médiane des débarquements de homard entre 1985 et 2009 est utilisée comme valeur approximative de $B_{RMS}$. En ce qui concerne le point de référence supérieur du stock et le point de référence limite, on propose les valeurs de 80 % et 40 %, comme il est recommandé dans le document d'orientation de Pêches et Océans Canada concernant l'application de l'approche de précaution. Ces valeurs ont été établies pour chacune des zones de pêche du homard. Pour les endroits où l'on a constaté des débarquements plus faibles de 1985 à 2009, dont la pêche s'est rétablie, on a utilisé le point le plus faible d'une moyenne mobile de trois ans à titre de point de référence limite.

Compte tenu des incertitudes et des mises en garde liées à l'utilisation de débarquements à titre de valeur approximative de la biomasse, les points de référence proposés devraient seulement être utilisés en tenant également compte des indicateurs secondaires. De plus, il faudrait prendre des mesures pour incorporer un indicateur indépendant quelconque de l'abondance du stock. Dans le cas de certaines zones de pêche du homard, des relevés indépendants de la pêche pourraient prendre la forme de relevés disponibles sur d'autres espèces enregistrant également le nombre de homards. On pourrait aussi établir des relevés périodiques sur le homard pour assurer une surveillance de la réponse aux mesures de conservation.

Pour les séries chronologiques disponibles (zones de pêche du homard 27 à 33), aucune tendance à la hausse de l'exploitation n'a été observée au cours des 11 à 12 dernières années. L'abondance du homard a continué d'augmenter au cours des 11 dernières années dans la plupart des zones. Dans les conditions actuelles, les stocks de homard semblent avoir été résilients malgré les niveaux d'exploitation enregistrés au cours de la dernière décennie ou plus.

## INTRODUCTION

Lobster landings in the Maritimes Region Lobster Fishing Areas (LFAs, Fig. 1) have been increasing since the 1980s and reached an all-time high in 2010 (Table 1, Fig. 2). The process to apply a precautionary approach (PA) to lobster fisheries in the Maritimes Region has been initiated. "Candidate" reference points (RPs) for all inshore LFAs are provided in the current IFMP (Integrated Fisheries Management Plan): Inshore Lobster Integrated Fishery Management Plan, Lobster Fishing Areas 27–38, Scotia-Fundy Sector, Maritimes Region 2011. These RPs are based on using landings as a proxy for biomass. An approach that uses landings as a biomass proxy has also been proposed for Magdalen Islands lobster (Gendron and Savard 2012).

The development of RPs for lobster in the Maritimes Region has been informed by Department of Fisheries and Oceans (DFO's) guidance document on applying the PA (DFO 2009), a workshop on applying the PA to input controlled fisheries (DFO 2011a), together with discussions with lobster fishermen. The PA approach and the candidate RPs have been presented at industry advisory meetings and a framework assessment for LFAs 27-33 (DFO 2011b, Tremblay et al. 2011).

The material presented here is a progress report on the steps towards a working PA for inshore lobster in the Maritimes Region. It should be regarded as a progress report. This document provides the rationale for using empirical (or "trend-based") RPs for lobsters and for using landings as a proxy for biomass in the near to medium term. In addition, the role of secondary indicators in applying the RPs, and in the application of harvest control rules. In addition, the role of secondary indicators in applying the RPs, and in the application of harvest control rules is discussed.

## DEVELOPMENT OF REFERENCE POINTS FOR LOBSTERS IN LFAS 27-38

### UNITS FOR APPLICATION OF REFERENCE POINTS

This document deals with all of the LFAs from northern Cape Breton to the Bay of Fundy (Fig. 1). It is understood that LFAs are not biological units in the sense that they are all self-sustaining. Connectivity across LFAs ranges from limited to substantial depending on LFA size and location. Exchange is likely greatest during the larval period. Exchange across LFAs at the benthic phase is thought to be more limited based on extensive tagging studies of juvenile and adult lobsters (see review in Tremblay et al. 2011). In general, lobsters move less on the Atlantic coast of Nova Scotia (LFAs 27-33) than in the Gulf of Maine and Bay of Fundy. Tagging studies in the Bay of Fundy demonstrate substantial mixing throughout the Bay of Fundy and along the Maine coast (Campbell and Stasko 1985, 1986).

In the recent framework assessment for LFAs 27-33 (Tremblay et al. 2011), a cluster analysis of landings from 1947 to the present indicated there were five LFAs or groups of LFAs with similar landings patterns: LFA 27, LFAs 28-32, LFA 33, LFA 34 and LFAs 35-38. LFAs 28-32 were assessed as a unit where possible.

Although LFAs are not biologically independent, management is at the level of the LFA. LFAs differ with respect to number of licenses, number of traps per license, seasons, minimum legal sizes and other measures. Most of the indicators of abundance are fishery-dependent and LFA specific, and, as a result, comparisons of stock abundance indicators across LFAs are not straightforward. Trawl surveys in the Gulf of Maine and Bay of Fundy may allow for evaluation at the level of the biological units, but additional analyses of these data sources are needed.

Connectivity among lobster stocks is now being evaluated through the Lobster Node of the Canadian Fisheries Research Network (CFRN). Studies are in progress to estimate potential connectivity of lobsters in different regions via larval drift by applying large-scale bio-physical models. Studies of the genetic structure of lobster stocks are also underway. This work will inform our understanding of lobster stock structure in Atlantic Canada.

For the purposes here, it is proposed that RPs continue to be applied to individual LFAs. Trends in adjacent management units, or trends best depicted at a larger scale (e.g. trawl survey catch rates) can be recognized at the level of secondary indicators.

## USE OF TREND-BASED REFERENCE POINTS

There are no working population models for Canadian lobster with which to set model-based reference points. There is a working model for American lobster in the U.S. (Chen et al. 2005, ASFMC 2009), and the application of this model to some lobster stocks in Atlantic Canada is under exploration (Tremblay 2011). There are working egg-per-recruit (e/r) and yield-per-recruit models which have been used to inform on stock health (e.g. Tremblay and Eagles 1998, Lawton et al. 1999, Pezzack et al. 1999), but the outcome from these models has been static in spite of the substantial changes in lobster abundance from the 1980s to the present. Egg-per-recruit has been shown to be negatively related to fishery yields (Miller and Hannah 2006), indicating that any e/r reference points must be tailored to the area and production regime.

It may be possible to base RPs for some Canadian lobster stocks on better proxies for biomass given successful application of the University of Maine population model. This model would also allow uncertainties to be better evaluated and for potential harvest control rules to be compared, but there is considerable work to be done in adapting the model to Canadian lobster stocks.

Until such a model can be applied, reference points based on biomass proxies are the best option.

## LANDINGS AS A PROXY FOR COMMERCIAL BIOMASS

Despite the importance of lobsters to most Maritimes communities along the coast, there are no fishery independent surveys directed at lobster anywhere within the Maritimes Region. Depending on the LFA, there are various trap catch rate indicators available but all data come from traps set during the commercial fishing season. For LFAs 34-38, there are some trawl or dredge surveys directed at other species that catch lobsters as a bycatch. The quality of lobster data collected on these surveys has improved in the last 6-12 years. These surveys (annual summer trawl survey, Individual Transferable Quota (ITQ) survey, scallop survey) provide data on lobster number and size for the last 6-12 years. Data on lobster number and or lobster weight are available for earlier years in these surveys. Landings are the only biomass proxy that has a significant time series (at least 20 years).

Landings have been inferred to be proxies for biomass in numerous papers evaluating stock structure and changes in lobster abundance (Campbell and Mohn 1983, Harding et al. 1983, Hudon 1994, Pezzack 1996). The argument is that effort is sufficiently high in most areas that 60-90% of the legal sized lobsters are removed annually and thus landings are a reasonable proxy for the fishable biomass.

## Evidence that Landings Reflect Commercial Biomass

Although there are clearly uncertainties in using landings as a proxy for biomass (see below), lobster landings in the Maritimes Region have more than tripled since 1985. Two lines of evidence indicate the increases are primarily the result of increased lobster abundance, and that increased fishing effort contributed to only part of the increase. These lines of evidence are: 1) the correlation between landings and trap catch rate; and 2) the correlation between landings and lobster catch in fishery independent surveys.

1. Positive relationship between landings and trap catch rate (CPUE).

   If the landings changes seen in the last 30 years were due to effort increases, a weak or nonexistent relationship between landings and CPUE would be expected. Analyses for the period 1992 to 2001 obtained strong correlations ($R^2$ of 0.70 to 0.96) between landings and CPUE for LFAs 27-30 (Tremblay and Reeves 2004). Analyses with a longer time period and additional CPUE data sources (documented in Tremblay et al. 2011, 2012), confirm moderate to strong positive relationships between landings and CPUE (Fig. 3). In LFAs 29-32, where landings increased substantially beginning in 2003, CPUE increased substantially as well. The evidence indicates that landings increases in these areas were mainly a reflection of higher abundance, not simply increased fishing effort.

2. Landings are correlated with number of lobsters per trawl set in LFA 34 ITQ survey.

   The ITQ survey was designed to sample groundfish in inshore areas not sampled by the annual trawl survey. Since its beginning in 1996, the ITQ survey has consistently captured lobsters, particularly at a subset of locations. The ITQ survey has recorded lobster numbers since 1996. To assess how the ITQ survey lobster CPUE related to landings, the catch rate of sizes that would be legal during the fishing season was estimated. Since 2005 lobsters have been measured and sexed, so, for this period, the ITQ catch rate of legal lobsters is readily estimated. For the years 1996-2004, it was assumed that the mean proportion above legal size from 2005-2011 was representative. The ITQ survey number per tow has trended upwards since 1996 (Fig. 4) and plots of landings on ITQ lobster CPUE are strongly positive (Fig. 5), indicating the landings changes in LFA 34 from 1996-2011 are largely due to abundance changes.

## Uncertainties and Caveats in Using Landings as a Biomass Proxy 1985-2009

1. Landings are affected by factors other than abundance.

   Landing levels are a function of abundance and a wide range of other factors, such as number of trap hauls, soak days, fishing strategy, catchability (affected by environmental factors, such as temperature and storms, as well as gear efficiency), and management rules. Changes in any of these can affect the relationship between landings and abundance. In addition, there is some uncertainty regarding how well recorded landings reflect true landings, particularly in the early days of the fishery.

2. Landings cannot reflect trends in the abundance of prerecruits and females with eggs.

3. Fishing effort has increased since the 1980s - nominal fishing effort increased in the 1980s and 1990s (FRCC 1995). Trap limits and license numbers have not increased, but fishermen responded to increased landings by fishing closer to the maximum allowed. On the eastern and south shores of Nova Scotia (LFAs 31-33), the number of trap hauls and

days fished increased from 1982 to 1988 and then remained stable or declined to 1998 (Duggan and Miller 2002). Fishing grounds have also expanded in some areas: off southwest Nova Scotia (LFA 34) in the 1980s and into the late 1990s and early 2000s (Duggan and Pezzack 1995, Pezzack et al. 2006) and in the Bay of Fundy from the early 1990s to 2006 (Robichaud and Pezzack 2007). Recent assessments have not detected increases in nominal fishing effort. From 1998-2004, total effort (numbers of traps hauled) had no trend in LFA 34 (Pezzack et al. 2006). Landings more than doubled in LFAs 27-33 from 1999-2010, but there was no consistent increase in effort or exploitation (Tremblay et al. 2012).

4. Fishing efficiency has increased due to larger boats, improvements to navigation and traps and fishing strategy (FRCC 2007). For example in LFA 34, overall vessel length increased by about 20% from 1985 to 2003 and the percent of vessels with brake horsepower >300 increased from about 15% in 1998 to over 40% in 2005 (Michael Campbell, Policy and Economics Branch, DFO, 2012, pers. comm.). The increase in fishing efficiency has not been quantified.

5. Landings are responsive to regulations change - if conservation measures change the harvestable portion of the stock, or alter the catchability in traps, landings before and after the conservation measures are not directly comparable.

6. Accurate landings are dependent on accurate records from industry. If the willingness to provide accurate data decreases, the use of landings as a biomass proxy is not tenable.

Given the above uncertainties and caveats, the use of landings as a biomass proxy should be used only with additional reference to secondary indicators. In addition, steps should be taken to incorporate some fishery independent indicator of abundance. This is particularly important if the current biomass proxies begin to approach the cautious zone. Fishery independent surveys could be in the form of existing surveys (ITQ, RV) possibly with additional stations. Alternatively, periodic directed lobster surveys could be established to monitor the response to conservation measures.

Landings provide a starting point for monitoring lobster stock abundance in the precautionary approach framework, but are not sufficient in the long term.

## UPPER AND LIMIT REFERENCE POINTS BASED ON LANDINGS AS A BIOMASS PROXY

Following DFO's guidance document (DFO 2009) Annex 1b, biomass at MSY ($B_{MSY}$) is estimated as the median of the biomass proxy (landings) over a productive period. The median rather than the mean is used as the frequency distribution of landings is skewed and the median gives less weight to the high landings seen in some areas in recent years. The DFO guidance document suggests a length for such a period be at least 1.5 to 2 generations. For lobster, a generation is on the order of 7-10 years and lobsters can easily live 20 years or more if not captured. Here the 25-year period from 1985-2009 is selected. This certainly represents a productive period, but also includes years when landings were substantially lower than at present. During this time period the quantity and quality of effort increased but other data indicate that the there was a significant increase in abundance independent of the effort increase.

In the IFMP, the time period 1985-2004 was used partly because discussion began on the topic in 2009, and inclusion of 2004-09 was not appropriate given landings were wanted from a fixed

period to compare with current landings. Adding the last 5 years better represents lobster production under the current conditions.

For the upper and limit reference points, the values of 80% and 40% of the $B_{MSY}$ proxy are used as suggested in the PA guidance document. Where there were observations of lower landings from 1985-2009 from which the fishery recovered, the lowest point of a 3-year running average is suggested as the limit reference point. These values are set out for each LFA in Table 2. To reduce the uncertainty of using landings from a single year, the use of a 3-year running mean of landings (mean of 3 most recent years) is recommended for deciding whether the biomass proxy was below the upper RP.

The upper reference point was seen as recently as 10 years ago in some eastern LFAs, but all of these LFAs adopted some conservation measures in the late 1990s and 2000s.

## UNCERTAINTIES

Uncertainties are mainly those associated with using landings as a biomass proxy and are discussed above. Some of these uncertainties can be reduced with reference to secondary indicators, e.g. (i) that landings are reported completely and accurately; and (ii) that landings changes continue to reflect biomass changes rather than other factors (e.g. changes in temperature or climate that affect catchability).

### Production Regime

A large uncertainty in the development of RPs for lobsters is the stability of the current lobster production regime. Lobster production now is much higher than in the1970s and early 1980s. Steneck et al. (2011) argue that the Gulf of Maine is now a simplified and arguably "domesticated" ecosystem that is dominated by species that were formerly prey of extirpated predators. In addition to high abundance, lobsters are now found more commonly on bottom types where they were uncommon in earlier periods (Boudreau and Worm 2010). The dominant hypothesis for the increase in lobster production in the Gulf of Maine is release from predation (Boudreau and Worm 2010, Steneck et al. 2011), but a shift to favourable physical environmental conditions may also have contributed.

Lobster production could remain high for some time to come, but increased fish abundance could increase mortality through predation. Although not an issue in any Canadian fishing areas now, the possibility of disease increasing natural mortality in the future cannot be ignored (Steneck et al. 2011). Lastly there is the uncertain effect that climate warming will have on the conditions for lobster production. All of these potential changes should be anticipated by monitoring secondary indicators. If there is a significant shift in the regime, redefinition of reference points should be considered.

## SECONDARY INDICATORS OF LOBSTER STOCK HEALTH

Given the uncertainties in using landings as a biomass proxy, and the fact that landings can only represent commercial biomass, other indicators are necessary. They may both (i) change the perception of stock status, and (ii) inform the type of response to a stock that has entered the cautious zone. Some of the secondary indicators could become "primary indicators" in the near future (next 5 years) with associated RPs. These RPs could be developed when time series are of sufficient length.

Available indicators vary from LFA to LFA. While landings are the only biomass proxy with a significant time series (at least 20 years), other catch rate based indices are now approaching 13-14 years in some LFAs. For some LFAs, some of these secondary indicators could become primary indicators within 5-6 years.

In some cases, it will be best to keep the secondary indicators separate by LFA, and to consider the indicators in adjacent interacting LFAs as an early warning system. In other cases, it may be most appropriate to display and consider secondary indicators grouped by a set of interacting LFAs.

Five groups of secondary indicators for lobster are considered:

1. Abundance/biomass (commercial sizes).
2. Production (recruitment, reproduction).
3. Demography (size structure, sex ratio).
4. Fishing Pressure (effort, exploitation).
5. Environment:
    a. Factors potentially affecting catchability (e.g. temperature, storms).
    b. Physical or biological factors affecting recruitment, growth, and survival, including predation, food availability and disease.

**Secondary Indicators - Abundance/Biomass**

Secondary indicators of commercial biomass, together with fishing effort and key indicators of lobster catchability, would be used to verify that changes in landings reflected abundance changes. This would be particularly important if the landings begin to approach the RP. If, for example, landings declined and commercial CPUE did not, then the distribution of fishing effort would be examined to assess whether it had decreased. This might explain the landings decline rather than abundance. Another example would be a decline in landings and CPUE. If temperature and storm activity were "normal", it would be concluded that commercial abundance had declined. If, on the other hand, during the fishing season bottom temperatures or storm activity was anomalous, the possibility that decreased catchability could explain the lower CPUE could be examined. Conclusions about the abundance trend would then be modified accordingly. By averaging the biomass proxy (landings) over 3 years it is less likely that annual differences in catchability would affect the reliability of the biomass proxy, but these factors need consideration.

Sources for trap CPUE data are available and in use to varying degrees for all LFAs: commercial logs, voluntary logs, and trap catch data from Fishermen and Scientists Research Society (FSRS) traps. Example indicators of this type are commercial CPUE in FSRS traps in LFAs 27, 29-32 and 33 (Tremblay et al. 2012). For the next assessment of LFA 34, a 14-year time series of commercial CPUE from mandatory logs should be available. For LFAs in the Gulf of Maine and Bay of Fundy, the catch of lobsters in trawl surveys shows promise as an additional indicator of lobster abundance.

## Other Secondary Indicators

The other secondary indicators would be used to assess overall stock health, and to inform the type of management action for a stock that has entered the cautious zone. Production and demography indicators provide information on the resilience of the stock to negative conditions; environmental indicators provide information on the degree to which conditions are favourable for lobster production. If indicators were turning negative, then it would be appropriate to apply conservation measures more aggressively. The type of conservation measure should be tailored to improve the negative indicator(s) if possible. If, for example, the cautious zone was entered and a decline in prerecruits (Production) was evident, a response involving increased egg production and decreased removals would be appropriate. If a decline in spawner abundance or egg production was noted, enhanced protection for spawners would be advised.

To assess the degree to which environmental conditions are favourable for lobster production, a suite of indicators is needed to monitor physical and biological factors affecting recruitment, growth and survival, including disease. Some of these are available now; others are in development. These are expected to change gradually with the exception of disease which could develop rapidly under some conditions. In any case, time series need to be developed.

## REMOVAL REFERENCE

Exploitation rate can be estimated for most LFAs using different approaches. These include length composition analysis, index removal methods, tagging methods and change-in-ratio. All methods come with their own assumptions, limitations, and requirements for certain types of data.

Most estimates of exploitation for inshore lobster fisheries are high (50-90% of harvestable sizes) and have been so for some time. In the early 1980s, estimates for the Bay of Fundy were 75% (F=1.4); for the eastern shore of Nova Scotia 47% (F= 0.63), and for Northumberland Strait 82% (F=1.7) (Campbell and Robinson 1983). Lobster stocks have been resilient in the face of high estimates of exploitation rates for at least 30 years. During this period, lobster abundance has increased substantially. This is likely due to a combination of sound conservation measures and favourable conditions for lobster recruitment and survival in the last 30 years.

Where time series are available (LFAs 27-33), there has been no upward trend in exploitation for the last 11-12 years. Lobster abundance has continued to increase during the last 11 years in most areas. Under current conditions, the population has been resilient to the levels of exploitation measured in the last decade or more. As such, if a limit removal reference is to be instituted, the 90$^{th}$ percentile of observations from 1999-2010 is suggested. Since the estimates are to some extent dependent on method, the method needs to be stated. These values for LFAs 27-33 are listed in Table 3. If the production regime changes to one that is less favourable to lobster populations, the current levels of exploitation would likely need to be reduced.

## FUTURE WORK

- Further explore data on lobsters captured in trawl surveys (ITQ, summer trawl, scallop surveys) and assess how the sampling design could be modified to better monitor lobster stock status. Develop abundance indicators(s) and RP as appropriate.
- Improve models of CPUE of commercial sizes, sublegal sizes and spawners; incorporate temperature if possible.
- Explore University of Maine model for application to one or more of Maritimes Regions LFAs.
- For all LFAs: (i) develop an alternative to landings as the sole biomass proxy; and (ii) where the alternative is not fishery-independent, develop protocols to conduct periodic fishery-independent surveys for application if the biomass proxy approaches the cautious zone.
- Evaluate how indicators for adjacent interacting management units can be incorporated into decision making, particularly as more is learned about connectivity through ongoing work.
- Develop (or use existing) indicators that would signal a change in the production regime either due to environmental factors or predator abundance.
- Develop (or use existing) indicators of lobster health and condition (disease monitoring, nutritional status).
- Evaluate rate of mating success and interaction with sex ratio, and assess effect on population egg production.

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*Table 1. Landings in LFAs 27-38.*

| SEASON | Annual | LFA27 | LFA28-29 | LFA30 | LFA31 | LFA32 | LFA33 | LFA34 | LFA35 | LFA36 | LFA38 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1946-47 | 1947 | 912 | 117 | 103 | 421 | 333 | 908 | 3130 | 122 | 212 | 277 |
| 1947-48 | 1948 | 962 | 110 | 171 | 421 | 285 | 1016 | 3284 | 110 | 286 | 350 |
| 1948-49 | 1949 | 862 | 151 | 164 | 451 | 275 | 1117 | 3761 | 155 | 230 | 302 |
| 1949-50 | 1950 | 898 | 177 | 162 | 589 | 384 | 1146 | 4172 | 80 | 251 | 339 |
| 1950-51 | 1951 | 1099 | 246 | 191 | 628 | 501 | 1296 | 4420 | 99 | 223 | 416 |
| 1951-52 | 1952 | 964 | 300 | 159 | 738 | 743 | 1151 | 3887 | 116 | 338 | 378 |
| 1952-53 | 1953 | 1081 | 254 | 244 | 825 | 587 | 1415 | 3973 | 155 | 292 | 450 |
| 1953-54 | 1954 | 1162 | 295 | 251 | 867 | 642 | 1177 | 3480 | 156 | 263 | 374 |
| 1954-55 | 1955 | 1245 | 296 | 298 | 800 | 476 | 1207 | 3282 | 124 | 277 | 409 |
| 1955-56 | 1956 | 916 | 282 | 265 | 711 | 440 | 1293 | 3441 | 111 | 313 | 371 |
| 1956-57 | 1957 | 708 | 215 | 258 | 705 | 231 | 827 | 2706 | 125 | 286 | 336 |
| 1957-58 | 1958 | 838 | 278 | 217 | 513 | 235 | 919 | 2268 | 115 | 254 | 388 |
| 1958-59 | 1959 | 882 | 444 | 108 | 516 | 247 | 1333 | 2215 | 147 | 247 | 261 |
| 1959-60 | 1960 | 953 | 285 | 159 | 472 | 360 | 1184 | 2606 | 151 | 257 | 311 |
| 1960-61 | 1961 | 955 | 211 | 162 | 309 | 228 | 1329 | 2305 | 158 | 328 | 256 |
| 1961-62 | 1962 | 970 | 183 | 172 | 501 | 603 | 1082 | 2548 | 141 | 278 | 237 |
| 1962-63 | 1963 | 843 | 140 | 142 | 525 | 690 | 1085 | 2896 | 168 | 308 | 311 |
| 1963-64 | 1964 | 778 | 105 | 107 | 374 | 397 | 1023 | 3221 | 153 | 228 | 287 |
| 1964-65 | 1965 | 899 | 77 | 77 | 275 | 322 | 960 | 2851 | 169 | 216 | 274 |
| 1965-66 | 1966 | 786 | 69 | 81 | 236 | 177 | 711 | 2708 | 184 | 206 | 283 |
| 1966-67 | 1967 | 774 | 54 | 59 | 243 | 200 | 549 | 2710 | 125 | 143 | 223 |
| 1967-68 | 1968 | 766 | 45 | 52 | 169 | 213 | 803 | 2844 | 152 | 179 | 283 |
| 1968-69 | 1969 | 540 | 44 | 43 | 186 | 229 | 1056 | 3888 | 142 | 258 | 430 |
| 1969-70 | 1970 | 713 | 43 | 40 | 213 | 263 | 836 | 4580 | 126 | 209 | 376 |
| 1970-71 | 1971 | 674 | 59 | 48 | 263 | 276 | 986 | 4066 | 140 | 187 | 362 |
| 1971-72 | 1972 | 641 | 61 | 43 | 222 | 194 | 616 | 4037 | 116 | 183 | 296 |
| 1972-73 | 1973 | 547 | 56 | 29 | 218 | 187 | 485 | 4457 | 159 | 145 | 308 |
| 1973-74 | 1974 | 748 | 43 | 30 | 162 | 141 | 595 | 3771 | 106 | 132 | 282 |
| 1974-75 | 1975 | 893 | 39 | 37 | 119 | 91 | 531 | 3973 | 108 | 99 | 321 |
| 1975-76 | 1976 | 749 | 29 | 39 | 110 | 86 | 382 | 3914 | 95 | 71 | 130 |
| 1976-77 | 1977 | 795 | 24 | 29 | 68 | 84 | 352 | 3463 | 118 | 65 | 362 |
| 1977-78 | 1978 | 838 | 20 | 20 | 48 | 53 | 213 | 2813 | 108 | 78 | 314 |
| 1978-79 | 1979 | 1014 | 34 | 19 | 51 | 49 | 416 | 3037 | 115 | 181 | 338 |
| 1979-80 | 1980 | 975 | 23 | 13 | 41 | 66 | 248 | 3229 | 71 | 160 | 233 |
| 1980-81 | 1981 | 1267 | 45 | 35 | 70 | 56 | 363 | 3060 | 126 | 167 | 367 |
| 1981-82 | 1982 | 1227 | 50 | 27 | 94 | 70 | 448 | 3663 | 143 | 235 | 406 |
| 1982-83 | 1983 | 1658 | 63 | 62 | 120 | 109 | 461 | 4546 | 136 | 225 | 378 |
| 1983-84 | 1984 | 1502 | 74 | 69 | 169 | 140 | 1044 | 5138 | 164 | 211 | 365 |
| 1984-85 | 1985 | 1721 | 113 | 60 | 183 | 180 | 1658 | 5938 | 226 | 266 | 334 |
| 1985-86 | 1986 | 2420 | 154 | 85 | 223 | 284 | 2385 | 6891 | 246 | 281 | 315 |
| 1986-87 | 1987 | 2763 | 200 | 99 | 303 | 258 | 2794 | 7673 | 330 | 328 | 339 |
| 1987-88 | 1988 | 3072 | 203 | 77 | 326 | 222 | 2589 | 8479 | 262 | 340 | 383 |
| 1988-89 | 1989 | 3714 | 257 | 132 | 482 | 239 | 1888 | 8201 | 270 | 309 | 467 |
| 1989-90 | 1990 | 3790 | 172 | 119 | 365 | 303 | 2037 | 9449 | 254 | 222 | 466 |
| 1990-91 | 1991 | 3526 | 168 | 151 | 401 | 298 | 2420 | 11071 | 228 | 271 | 496 |
| 1991-92 | 1992 | 2778 | 150 | 167 | 358 | 304 | 1849 | 8876 | 254 | 249 | 512 |
| 1992-93 | 1993 | 2458 | 104 | 132 | 284 | 279 | 1731 | 8916 | 239 | 257 | 471 |
| 1993-94 | 1994 | 2190 | 104 | 130 | 240 | 262 | 1968 | 10326 | 241 | 274 | 523 |
| 1994-95 | 1995 | 2141 | 107 | 126 | 229 | 219 | 1395 | 9692 | 311 | 317 | 648 |
| 1995-96 | 1996 | 1616 | 75 | 90 | 176 | 225 | 1825 | 10307 | 546 | 421 | 600 |
| 1996-97 | 1997 | 1398 | 51 | 80 | 148 | 243 | 1867 | 10593 | 731 | 666 | 540 |
| 1997-98 | 1998 | 1347 | 64 | 70 | 200 | 309 | 2104 | 11886 | 846 | 753 | 695 |
| 1998-99 | 1999 | 1425 | 55 | 70 | 217 | 316 | 2162 | 12993 | 956 | 813 | 806 |
| 1999-00 | 2000 | 1505 | 59 | 54 | 299 | 448 | 2297 | 13514 | 932 | 863 | 826 |
| 2000-01 | 2001 | 1819 | 71 | 98 | 304 | 433 | 2521 | 16503 | 1091 | 997 | 983 |
| 2001-02 | 2002 | 1395 | 65 | 79 | 313 | 358 | 2753 | 19054 | 1284 | 1220 | 1137 |
| 2002-03 | 2003 | 1659 | 138 | 73 | 432 | 389 | 2320 | 17613 | 1234 | 1169 | 1134 |
| 2003-04 | 2004 | 1850 | 198 | 84 | 518 | 289 | 1955 | 17801 | 1337 | 1201 | 1038 |
| 2004-05 | 2005 | 2036 | 411 | 112 | 925 | 403 | 2519 | 17250 | 1172 | 1067 | 1074 |
| 2005-06 | 2006 | 1966 | 668 | 187 | 1497 | 602 | 2556 | 16991 | 1227 | 1320 | 1674 |
| 2006-07 | 2007 | 2024 | 800 | 216 | 1888 | 632 | 3033 | 16796 | 1191 | 1124 | 1413 |
| 2007-08 | 2008 | 2849 | 1089 | 413 | 1993 | 704 | 2599 | 16641 | 1468 | 1436 | 1805 |
| 2008-09 | 2009 | 2178 | 1099 | 452 | 2227 | 829 | 3402 | 17733 | 1684 | 1546 | 1594 |
| 2009-10 | 2010 | 2568 | 926 | 371 | 1912 | 657 | 3376 | 19620 | 1982 | 1506 | 1851 |

*Table 2. Upper stock reference (USR) and limit reference points (LRP) by LFA (based on landings). Recommended LRP is highlighted in bold. Last column is lowest point of 3-year running average of the landings.*

| LFA | $B_{MSY}$ proxy (median 1985-2009) | USR (80%) | LRP (40%) | Lowest observed 1985-2009 |
|---|---|---|---|---|
| 27 | 2036 | 1629 | **814** | 1390 |
| 28-29 | 150 | 120 | 60 | **57** |
| 30 | 99 | 79 | **40** | 65 |
| 31 | 313 | 250 | **125** | 175 |
| 32 | 303 | 242 | **121** | 229 |
| 33 | 2297 | 1838 | **919** | 1696 |
| 34 | 11071 | 8857 | **4428** | 6834 |
| 35 | 731 | 585 | 292 | **240** |
| 36 | 666 | 533 | 266 | **247** |
| 38 | 648 | 518 | 259 | 329 |
| | | | | |

*Table 3. Removal reference levels ($90^{th}$ percentile of estimates for time period). Based on size class between minimum legal size and 90 mm carapace length (CL), males and female estimates averaged. Modified from data presented in Tremblay et al. 2011.*

| LFA | Method | Time period | Limit removal |
|---|---|---|---|
| 27 | CCIR | 1999-2010 | 0.86 |
| 29 | CCIR | 2000-2010 | 0.79 |
| 30 | CCIR | 2000-2010 | 0.86 |
| 31 | CCIR | 2000-2010 | 0.77 |
| 32 | CCIR | 1999-2010 | 0.82 |
| 33 | CCIR | 1999/2000 – 2009/2010 | 0.81 |

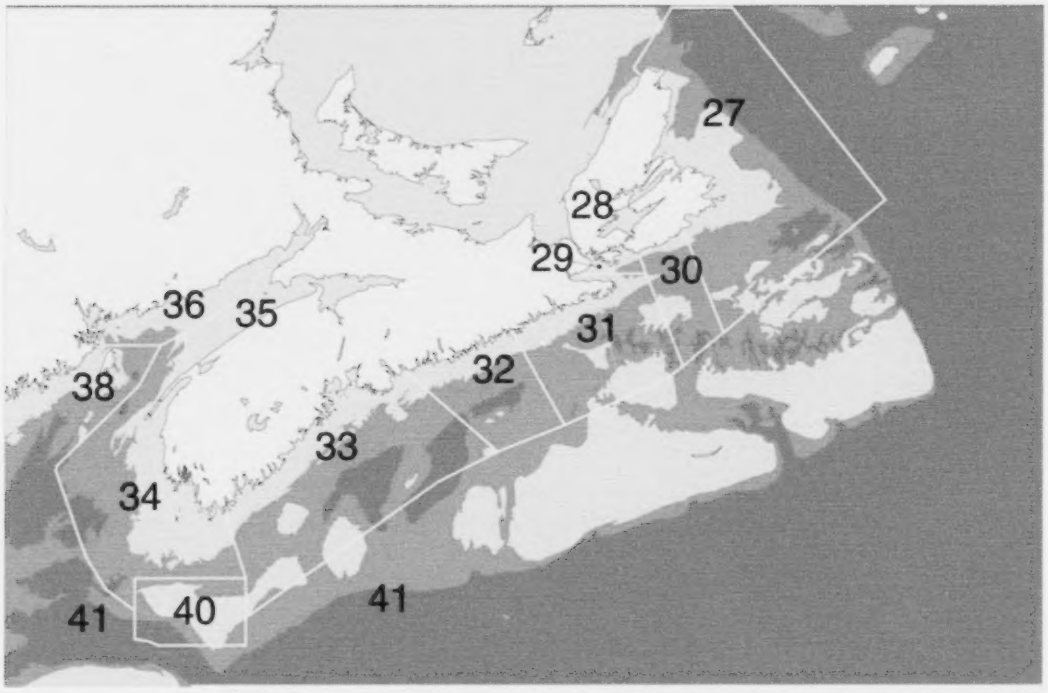
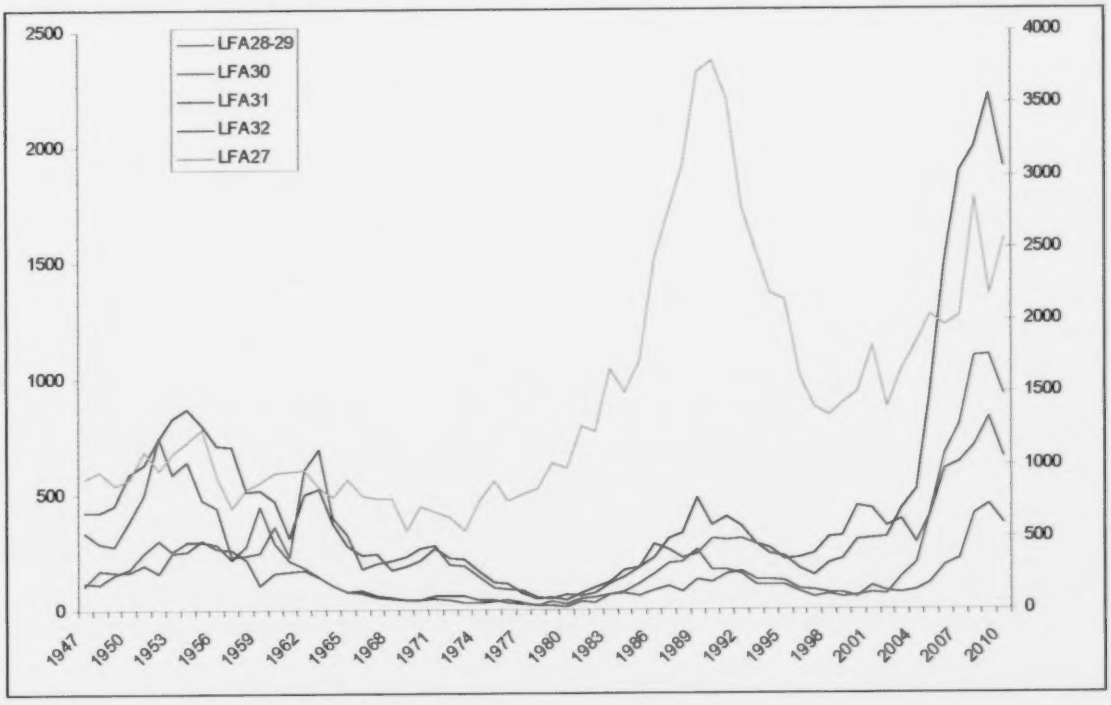



*Figure 1. Maritimes Region Lobster Fishing Areas (LFAs). LFA 40 is closed to lobster fishing.*



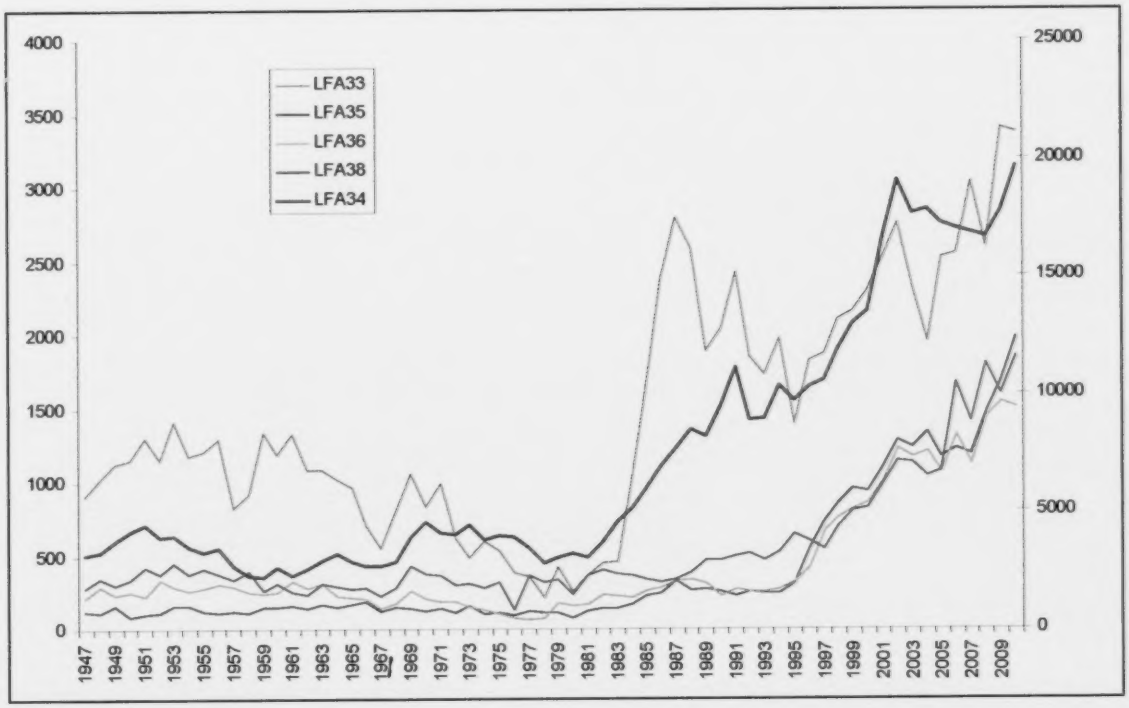




*Figure 2. Landings (t) by LFA, 1947-2010.*

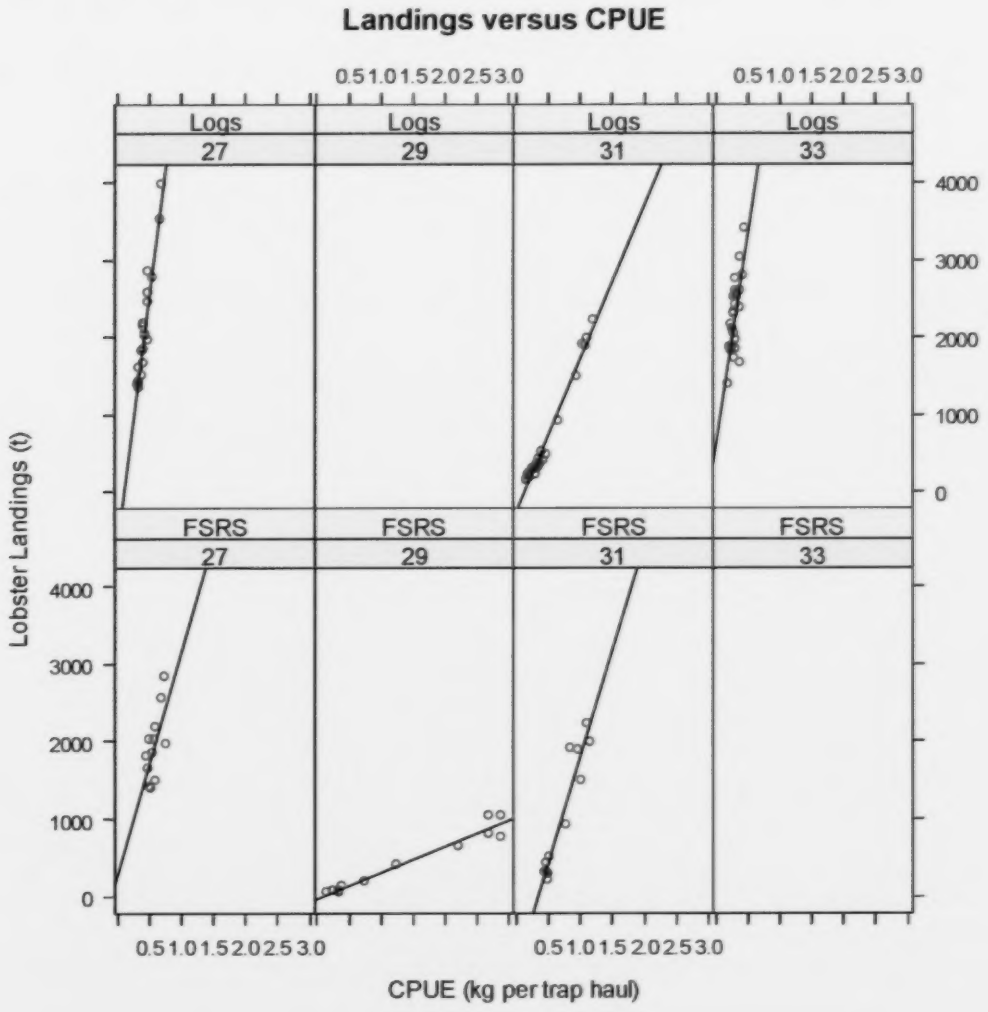



*Figure 3. Landings versus catch rate (CPUE in kg per trap haul) for different LFAs and data sources (logs and Fishermen and Scientists Research Society [FSRS]). Log data originates from voluntary or mandatory logs of daily catch and effort maintained by fishermen. Data years from logs are as follows: LFA 27: 1990-2010 (voluntary logs 1990-2007; mandatory logs 2008-2010); LFA 31: LFA 31, 1985-2010 (voluntary logs 1985-2005, mandatory logs, 2006-2010); and LFA 33: 1984-85 to 2008-09 (all voluntary logs). FSRS data originate from the FSRS recruitment trap project. Data years for each LFA are 1999-2010. FSRS data points are from a standardized CPUE model based on number per trap haul converted to kg per trap haul using the median carapace length measured in port samples together with a carapace length-weight relationship.*

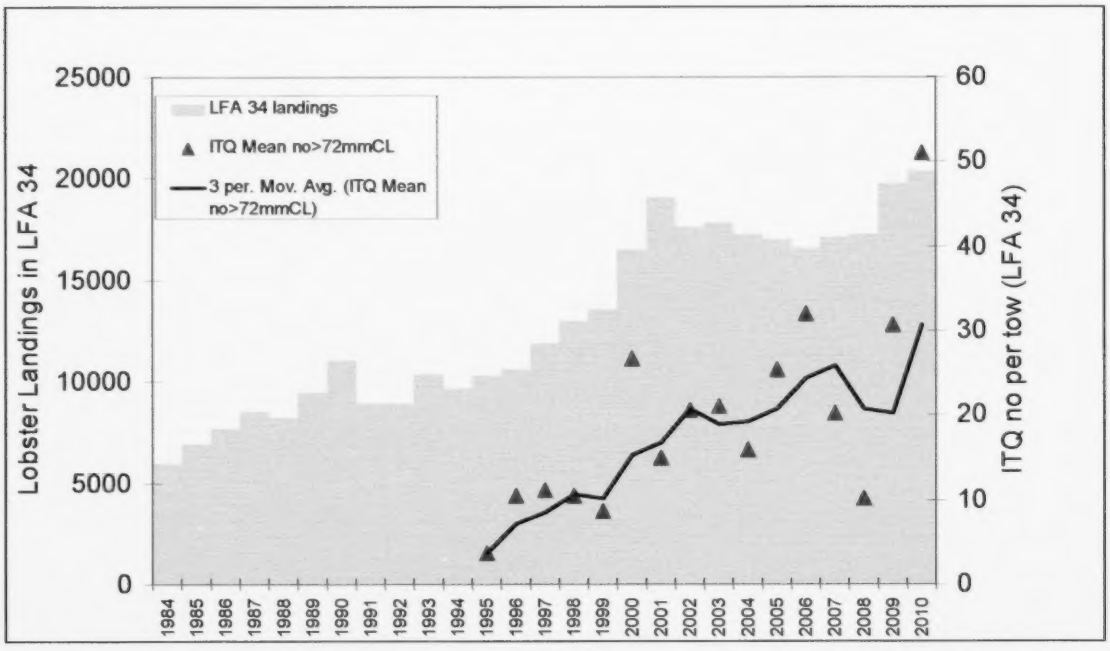



*Figure 4. Trends in LFA 34 from 1984 to 2010: lobster landings and ITQ mean number of lobsters per tow.*

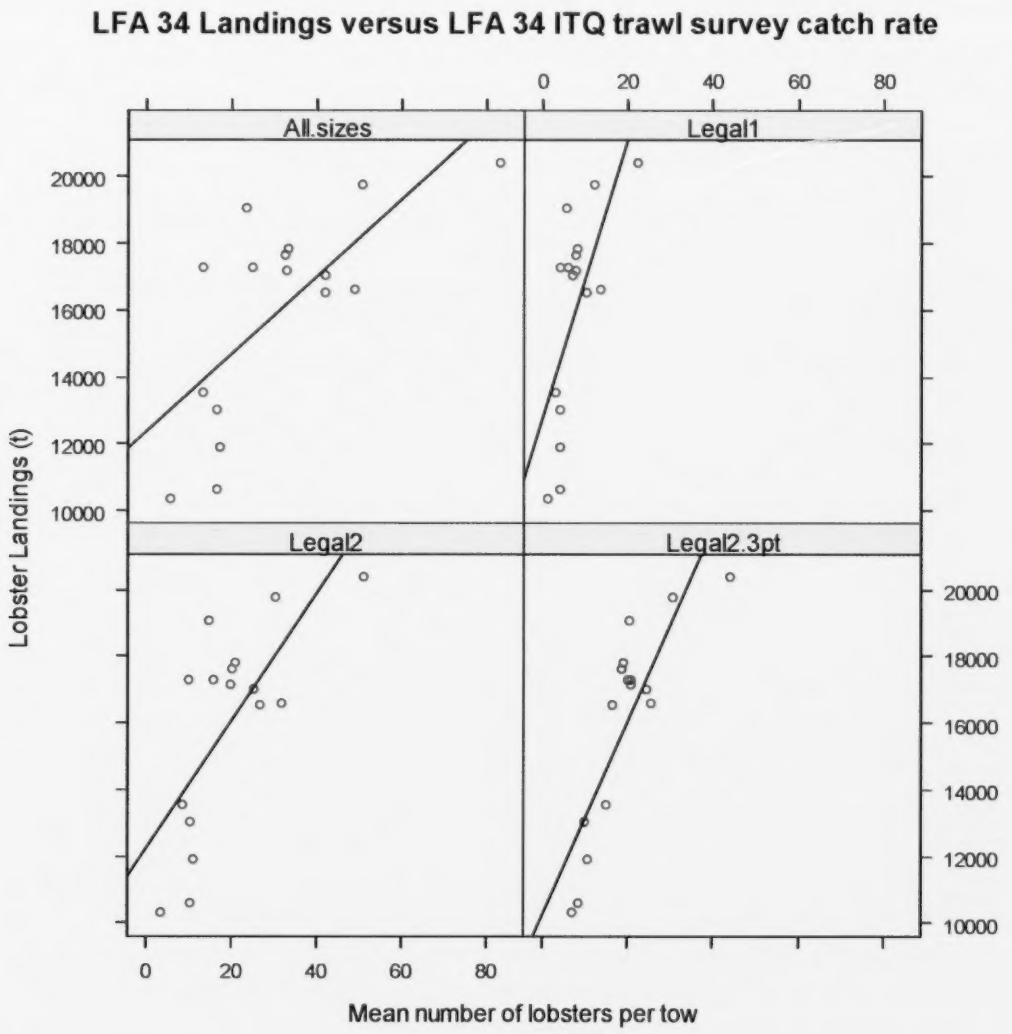



*Figure 5. Landings in LFA 34 versus mean number of lobsters per tow in Individual Transfer Quota (ITQ) survey in LFA 34. All.sizes is full size range of lobsters; Legal1 is lobsters that were of legal size (>82.5 mm CL) during the ITQ survey in July; Legal2 is lobsters that were > 72 mm CL in July and are expected to have moulted to legal size by the time of the fishery in late fall; Legal3.3pt is a 3-point running average of Legal2.*